Dominion

OCT 18 2002

Docket No. 50-336
B18785

RE: 10 CFR 50.90

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555

Millstone Power Station, Unit No. 2
Request for Additional Information: Licensing Basis Document
Change Request 2-12-02, Unit No. 2 Technical Specification Change
Operation With Main Steam Line Code Safety Valves Inoperable

Dominion Nuclear Connecticut, Inc., requested in a letter dated August 1, 2002,[1] to amend Operating License No. DPR-65 by revising Millstone Unit No. 2 Technical Specification 3.7.1.1, "Plant Systems: Turbine Cycle Safety Valves," to reflect results of a reanalysis of overpressurization events to reinstate the capability to operate with up to four main steam line code safety valves in each main steam line inoperable.

On September 19, 2002, a request for additional information (RAI)[2] from the U.S. Nuclear Regulatory Commission (NRC) was received in preparation for a conference call held on September 26, 2002. During this conference call, a copy of the analyses supporting the proposed changes was also requested by the NRC. Attachment 1 provides the information requested within the RAI. Enclosure 1 provides a non-proprietary version of the vendor report[3] discussing the methodology used and the results of the analyses.

There are no regulatory commitments contained in this letter.

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(1)   Millstone Nuclear Power Station, Unit No. 2, Licensing Basis Document Change Request 2-12-02, "Unit No. 2 Technical Specification Change, Operation With Main Steam Line Code Safety Valves Inoperable," dated August 1, 2002, (B18645).

(2)   Facsimile from R. Ennis, USNRC, to R. Joshi, Dominion Nuclear Connecticut, Inc., "Issues for Discussion in Upcoming Telephone Conference Regarding Proposed Amendment to Technical Specifications, Operation With Main Steam Line Code Safety Valves Inoperable," dated September 19, 2002.

(3)   Report EMF-2733 Rev 0, "Millstone Unit 2 Analysis of the Loss-of-External-Load/Turbine Trip and Single MSIV Closure Events With Inoperable MSSVs," Framatome ANP, dated April 2002.

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If you should have any questions regarding this submittal, please contact Mr. Ravi Joshi at (860) 440-2080.
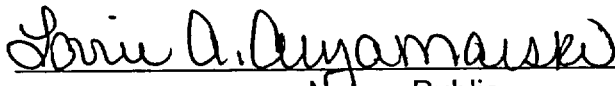
Very truly yours,

DOMINION NUCLEAR CONNECTICUT, INC.

J. Alan Price
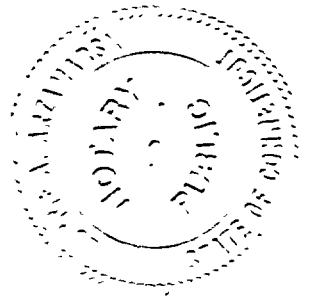Site Vice President - Millstone

Subscribed and sworn to before me

this ___18th___ day of __October__, 2002

_____
Notary Public

Date Commission Expires: _2/28/2006_

Lorrie A. Arzamarski
Notary Public
Commission Expires
February 28, 2006

Attachment: 1) Millstone Power Station, Unit No. 2, Request for Additional Information: Licensing Basis Document Change Request 2-12-02, Technical Specification Change, Operation With Main Steam Line Code Safety Valves Inoperable

Enclosure: 1) Millstone Unit 2 Analysis of the Loss-of-External-Load/Turbine Trip and Single MSIV Closure Events With Inoperable MSSVs, Framatome ANP Report EMF-2733, Rev. 0

cc: H. J. Miller, Region I Administrator
R. B. Ennis, NRC Senior Project Manager, Millstone Unit No. 2
Millstone Senior Resident Inspector

Director
Bureau of Air Management
Monitoring and Radiation Division
Department of Environmental Protection
79 Elm Street
Hartford, CT 06106-5127

Attachment 1

Millstone Power Station, Unit No. 2

Request for Additional Information: Licensing Basis Document
Change Request 2-12-02, Technical Specification Change,
<u>Operation With Main Steam Line Code Safety Valves Inoperable</u>

Millstone Power Station, Unit No. 2
Request for Additional Information: Licensing Basis Document
Change Request 2-12-02, Technical Specification Change
Operation With Main Steam Line Code Safety Valves Inoperable

DISCUSSION

In a letter dated August 1, 2002,[1] Dominion Nuclear Connecticut, Inc. requested to revise Millstone Unit No. 2 Technical Specification (TS) 3.7.1.1, "Plant Systems: Turbine Cycle Safety Valves," to reflect results of a reanalysis of overpressurization events to reinstate the capability to operate with up to four main steam line code safety valves (MSSVs) in each main steam line inoperable.

On September 19, 2002, a request for additional information[2] from the U.S. Nuclear Regulatory Commission (NRC) was received containing several questions in preparation for a conference call held on September 26, 2002. Answers to each question are provided below. The Millstone Unit No. 2 specific analyses supporting the proposed changes are presented in Enclosure 1, a non-proprietary version of the vendor report,[3] which discusses the methodology used and the results of the analyses.

QUESTIONS

1) **Was the reanalysis performed using computer codes and methods that were approved by the NRC staff?**

The Framatome Advanced Nuclear Power (ANP) Non-Loss of Coolant Accident (LOCA) methodology[4] using the S-RELAP computer code has been reviewed and approved[5] by the NRC. The methodology is referenced in the Millstone Unit No 2 TS Core Operating Limits Report (COLR) specification as item 6.9.1.8.b.15. Application of this methodology for Millstone Unit No. 2 was

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[1] Millstone Nuclear Power Station, Unit No. 2, Licensing Basis Document Change Request 2-12-02, "Unit No. 2 Technical Specification Change, Operation With Main Steam Line Code Safety Valves Inoperable," dated August 1, 2002, (B18645).

[2] Facsimile from R. Ennis, USNRC, to R. Joshi, Dominion Nuclear Connecticut, Inc., "Issues for Discussion in Upcoming Telephone Conference Regarding Proposed Amendment to Technical Specifications, Operation With Main Steam Line Code Safety Valves Inoperable," dated September 19, 2002.

[3] Report EMF-2733 Rev. 0, "Millstone Unit 2 Analysis of the Loss-of-External-Load/Turbine Trip and Single MSIV Closure Events With Inoperable MSSVs," Framatome ANP, April 2002.

[4] Report EMF-2310(P)(A), Revision 0, "SRP Chapter 15 Non-LOCA Methodology for Pressurized Water Reactors," Framatome ANP Richland Inc., May 2001.

[5] Letter from S A. Richards, USNRC, to J. F. Mallay, Siemens Power Corporation, "Acceptance For Referencing of Licensing Topical Report EMF-2310(P), Revision 0, 'SRP Chapter 15 Non-LOCA Methodology for Pressurized Water Reactors,' (TAC No. MA7192)," May 11, 2001.

approved[6] in an NRC Safety Evaluation Report for Amendment No. 260 which revised the COLR to include this methodology, dated December 19, 2001.

2) **Which computer code(s) and methodology was used for the reanalysis?**

The Loss of External Load/Turbine Trip (LOEL/TT) and Single Main Steam Isolation Valve (MSIV) Closure analyses have been performed in accordance with the approved Framatome ANP Non-LOCA methodology.[4] As discussed in this report, the methodology utilizes the S-RELAP5 plant transient thermal-hydraulic computer code to simulate the overall response of the reactor coolant and steam systems during the transient.

3) **Discuss your method of analysis to determine the maximum power levels and corresponding high trip setpoints for the values shown in proposed TS Table 3.7.1.**

For a detailed description of the analysis, refer to Enclosure 1.[3] Instead of using equations to extrapolate the full power analysis results to partial power levels, explicit S-RELAP5 analyses were performed to demonstrate the acceptability of the proposed power level limits. With the exception of the power level and the allowed inoperable MSSVs, the same assumptions as described in Chapter 14, "Safety Analysis," of the Millstone Unit No. 2 Final Safety Analysis Report (FSAR) were utilized. (Note, Millstone Unit No. 2 predates the Standard Review Plan. Chapter 14 of the Millstone Unit No. 2 FSAR corresponds to Chapter 15 of the FSAR for more recent plants.)

The calculated maximum primary and secondary pressures presented in Tables 2.1 through 2.3 of Reference 3 are summarized below. As indicated by the results, the analysis demonstrates that the single MSIV closure event is more limiting with respect to acceptable partial power levels for plant operation with three and four inoperable MSSVs in each steam line.

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[6] Letter from J. T. Harrison, USNRC, to J. A. Price, Dominion Nuclear Connecticut, Inc , Millstone Nuclear Power Station, Unit No. 2 - Issuance of Amendment Re: Number Revision to List of Documents in Technical Specification 6.9.1.8b (TAC No. MA1780), dated December 19, 2001.

Table 2.1, Summary of LOEL/TT Primary Pressurization Analysis Results

Initial Power (%RTP)	Number of Inoperable MSSVs in Each Steam Line	Peak Primary Pressure (psia)	Time of Peak Pressure (seconds)
85	1	2716.3	7.3
75	2	2712.5	7.8
65	3	2709.5	8.5
55	4	2703.4	9.4

Table 2.2, Summary of LOEL/TT Secondary Pressurization Analysis Results

Initial Power (%RTP)	Number of Inoperable MSSVs in Each Steam Line	Peak Secondary Pressure (psia)	Time of Peak Pressure (seconds)
85	1	1086.3	13.1
75	2	1087.4	14.3
65	3	1088.4	15.7
55	4	1088.1	17.9

Table 2.3, Summary of Single MSIV Closure Analysis Results

Initial Power (%RTP)	Number of Inoperable MSSVs in Each Steam Line	Peak Secondary Pressure (psia)	Time of Peak Pressure (seconds)
85	1	1092.2	20.0
75	2	1090.9	32.0
60	3	1085.1	15.2
45	4	1086.2	68.5

Based on the above results, taken from Reference 3, it has been concluded that plant operation in accordance with the proposed TS Table 3.7.1 power levels will assure that pressure relief capacities are sufficient to limit the primary and secondary system pressures to less than 110% of their design limits, i.e., 2750 and 1100 psia respectively.

As shown by Table 4.4, "Reactor Trip Setpoints and Delays," in Reference 3, the analyses do not credit the high power reactor trip. The high power trip setpoints shown in proposed TS Table 3.7.1 were chosen to be consistent with TS 2.2.1, "Reactor Trip Setpoints." As described in TS 2.2.1, the Millstone Unit No. 2

Power Level-High trip setpoint is operator adjustable and can be set no higher than 9.6% above the indicated thermal power level. The trip setpoint is automatically decreased as thermal power decreases.

Enclosure 1

Millstone Power Station, Unit No. 2

Millstone Unit No. 2 Analysis of the Loss-of-External-Load/Turbine Trip and Single
MSIV Closure Events With Inoperable MSSVs, Framatome ANP Report EMF-2733

FRAMATOME ANP

Millstone Unit 2 Analysis of the Loss-of-External-Load/Turbine Trip and Single MSIV Closure Events With Inoperable MSSVs

April 2002

Framatome ANP, Inc.
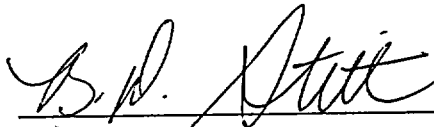
Framatome ANP, Inc.

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Revision 0

Millstone Unit 2 Analysis of the Loss-of-External-Load/Turbine Trip and Single MSIV Closure Events With Inoperable MSSVs

Prepared: _____   4-11-02
B. D. Stitt, Engineer   Date
PWR Safety Analysis

Contributors: L. H. Nielsen, Consultant
Nielsen Engineering

T. H. Chen, Engineer
PWR Safety Analysis

Approved: _____ for Cudlin   4/11/02
J. J. Cudlin, Manager   Date
Analysis Services / PWR Safety Analysis

Approved: _____   4/11/02
J. S. Holm, Manager   Date
Product Licensing

Approved: _____   _____
R. D. Williamson, Project Manager   Date
Contract Management and Proposals

:dar

Framatome ANP, Inc.

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Millstone Unit 2 Analysis of the Loss-of-External-Load/Turbine Trip and Single MSIV Closure Events With Inoperable MSSVs

Prepared:
_____   _____

B. D. Stitt, Engineer   Date
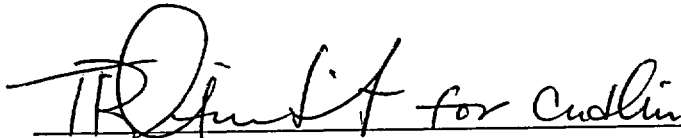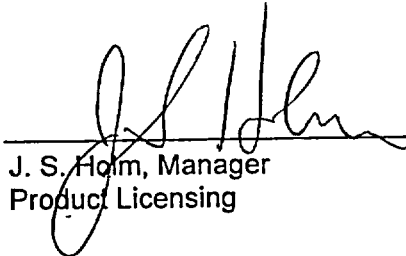PWR Safety Analysis

Contributors: L. H. Nielsen, Consultant
Nielsen Engineering

T. H. Chen, Engineer
PWR Safety Analysis

Approved:
_____   _____

J. J. Cudlin, Manager   Date
Analysis Services / PWR Safety Analysis

Approved:
_____   _____

J. S. Holm, Manager   Date
Product Licensing

Approved: ~~R. D. Williamson~~   *4/11/2002*

R. D. Williamson, Project Manager   Date
Contract Management and Proposals

:dar

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Important Notice Regarding the Contents and Use of This Document

Please Read Carefully

Millstone Unit 2 Analysis of the Loss-of-External-Load/Turbine Trip and Single
MSIV Closure Events With Inoperable MSSVs

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Nature of Changes

Item	Page	Description and Justification
1.	All	This is a new document.

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Nomenclature

CEA	Control element assembly
DNB	Departure from nucleate boiling
DNBR	Departure from nucleate boiling ratio
FRA-ANP	Framatome ANP, Inc.
HTP	High thermal performance
LHR	Linear heat rate
LOCA	Loss of Coolant Accident
LOEL/TT	Loss of Electrical Load / Turbine Trip
MDNBR	Minimum departure from nucleate boiling ratio
MFW	Main feedwater
MSIV	Main steam isolation valve
MSSV	Main steam safety valve
MTC	Moderator temperature coefficient
PORV	Power operated relief valve
PWR	Pressurized water reactor
RCP	Reactor coolant pump
RCS	Reactor coolant system
RPS	Reactor protection system
RTP	Rated thermal power
SAFDL	Specified acceptable fuel design limits
SG	Steam generator
TCV	Turbine control valve

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1.0   Introduction

This report documents analyses for a LOEL/TT transient and a Single MSIV Closure transient initiated at reduced power levels with inoperable MSSVs for the Millstone Unit 2 nuclear power plant. These analyses address the potential for over-pressurization of the primary and secondary systems resulting from both events. The results will be used to establish a new Technical Specification for Millstone Unit 2 which would allow reduced power operation with up to four MSSVs in each steam line out of service.

In order to support this Technical Specification, the LOEL/TT and Single MSIV Closure events, with up to four MSSVs in each steam line inoperable, were analyzed to confirm that the over-pressurization limits on the secondary system are not exceeded, therefore, demonstrating that sufficient capacity of operable safety valves exists for all operating power levels. Overpressure protection for the primary system is also confirmed by the LOEL/TT event performed at reduced power conditions.

The LOEL/TT analysis conservatively assumes the total loss of main feedwater coincident with the loss of load. For the secondary over-pressurization cases, it is assumed that there are no tubes plugged in the steam generators. The time to reach the reactor high pressure trip is maximized by enabling the pressurizer spray system and by disabling positive reactivity feedbacks. These assumptions maximize the pressure increase of the secondary system and provide the greatest challenge to the secondary side overpressure limit. The LOEL/TT analysis for primary over-pressurization is biased to produce the largest increase in primary system pressure. The biasing includes maximum tube plugging (500 per generator) and disabling the pressurizer sprays and PORVs.

The Single MSIV Closure analysis for secondary over-pressurization likewise assumes a total loss of MFW to the isolated steam generator to conservatively bound the reduction in feedwater flow that would occur during the transient. MFW to the non-isolated steam generator is set to match the steam demand from that generator. The analysis is biased as in the LOEL/TT secondary over-pressurization cases to maximize the secondary side pressure increase.

These analyses are not limiting with respect to DNB because they are initiated from reduced power conditions.

Framatome ANP, Inc.

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This analysis is based on FRA-ANP's approved methodology (Reference 1) for analyzing non-LOCA transient events. Four cases for each event, assuming up to four inoperable MSSVs in each steam line, were analyzed. The LOEL/TT cases were performed with the initial reactor powers at 85%, 75%, 65%, and 55% RTP with from one MSSV to four MSSVs inoperable, respectively. In all cases, the lowest setpoint MSSVs in each steam line were disabled up to the desired number of inoperable valves.

The Single MSIV Closure cases were performed with the initial reactor powers at 85%, 75%, 60%, and 45% RTP with from one MSSV to four MSSVs inoperable, respectively. In the 85% and 75% cases, the highest setpoint MSSVs in each steam line (up to the desired number of inoperable valves) were disabled, and in the 60% and 45% cases, the lowest setpoint MSSVs in each steam line (up to the desired number of inoperable valves) were disabled. These configurations gave the maximum secondary side pressures.

Section 2.0 of this report presents a summary of the analysis results and conclusions. Section 3.0 contains a description of the analytical model used in the analysis and Section 4.0 summarizes the input conditions. The analyses performed are presented in Sections 5.0 and 6.0. References are presented in Section 7.0.

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2.0   Summary

A summary of the calculated maximum primary and secondary pressures is presented in Table
2.1 through Table 2.3. The analysis demonstrates that the pressure relief capacities are sufficient
to limit the system pressures to less than 110% of their design limits.

Four cases were analyzed for each event, assuming up to four inoperable MSSVs in each steam
line. For the LOEL/TT event, initial power levels ranging from 85% to 55% RTP were used. The
Single MSIV Closure cases used power levels ranging from 85% to 45%. Each case included a
2% of rated thermal power uncertainty added to the initial power level. The peak pressures
were determined in the secondary system from the nodal volume immediately above the steam
generator tubesheet. In the primary system, the peak pressure is found in the reactor vessel
lower head volume.

The results show that the calculated maximum secondary coolant system pressure is less than
110% of the design value, or 1100 psia. Results from the LOEL/TT cases biased to maximize the
primary system over-pressurization also show that the calculated primary coolant system
pressure is less than 110% of the design pressure, or 2750 psia. The maximum pressurizer level
is significantly below the top of its indicating range. Therefore, no liquid is expelled out of the
pressurizer. These results show that the operable MSSVs provide adequate heat removal
capability to maintain the plant in a safe condition at the allowed power levels during the LOEL/TT
and Single MSIV Closure events.

This analysis supports the implementation of the Technical Specification limit regarding reduced
power operation with inoperable MSSVs.

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Table 2.1 Summary of LOEL/TT Primary Pressurization Analysis Results

Initial Power (%RTP)	Number of inoperable MSSVs in each steam line	Peak Primary Pressure (psia)	Time of Peak Pressure (s)
85	1	2716.3	7.3
75	2	2712 5	7.8
65	3	2709 5	8.5
55	4	2703.4	9.4

Table 2.2 Summary of LOEL/TT Secondary Pressurization Analysis Results

Initial Power (%RTP)	Number of inoperable MSSVs in each steam line	Peak Secondary Pressure (psia)	Time of Peak Pressure (s)
85	1	1086.3	13.1
75	2	1087.4	14.3
65	3	1088.4	15.7
55	4	1088.1	17.9

Table 2.3 Summary of Single MSIV Closure Analysis Results

Initial Power (%RTP)	Number of inoperable MSSVs in each steam line	Peak Secondary Pressure (psia)	Time of Peak Pressure (s)
85	1	1092.2	20.0
75	2	1090.9	32.0
60	3	1085.1	15.2
45	4	1086.2	68.5

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3.0   Analytical Methodology

The LOEL/TT and Single MSIV Closure analyses presented in this report have been performed in accordance with the approved FRA-ANP Non-LOCA methodology (Reference 1).

3.1   *S-RELAP5*

For each case analyzed, the S-RELAP5 plant transient thermal-hydraulic code was used to simulate the overall response of the reactor coolant and steam systems during the transient. The S-RELAP5 model includes a thermal model of the fuel, a hydraulic model of the RCS, a point-kinetics model of the reactor core, a hydraulic model of the steam system, and control logic which represents various RPS trips.

The RCS hydraulic model simulates the hot legs, pressurizer, steam generators (primary sides), cold legs, RCPs, reactor vessel, and core. For conservative simulation of the Single MSIV Closure cases, the reactor vessel downcomer and the core are separated into two sectors (for coolant from the affected and unaffected RCS loops). The variation in the core power fractions of the affected and unaffected sectors during the transient is modeled using results from a three-dimensional, two-group diffusion theory neutronics analysis code (PRISM, Reference 2).

The steam system hydraulic model simulates the steam generators (secondary sides) and integral steam flow restrictors, main steam lines, and turbine. The MSSVs and associated inlet piping were individually modeled. Since the safety valve actuation is based on the actual inlet pressure upstream of the valve, the pressure drop from the steam dome to the safety valve must be considered. Therefore, the model included the MSSV inlet piping configuration, with MSSV actuation based on the pressure immediately upstream of each valve. The opening setpoint of each valve is the nominal setpoint pressure plus a 3% tolerance. The closing pressure of each valve is modeled with an 8% blowdown from the nominal setpoint pressure, based on the immediately upstream pressure, to prevent valve chatter during the calculation. The model also included the inlet piping directly connected to the pressurizer safety valves. An 8% blowdown from the nominal setpoint pressure was also modeled for the pressurizer safety valves to prevent valve chatter during the calculation. No credit is taken for the non-safety-grade condenser dump or atmospheric dump systems.

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4.0   Input Conditions and Assumptions

The initial conditions used for the analyses are listed in Table 4.1, and other conditions assumed for the cases are listed in Table 4.2. The neutronic conditions assumed for all cases are listed in Table 4.3. The reactor trip setpoints and delays used in the analyses are listed in Table 4.4.

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Table 4.1 Initial Conditions

Reactor Power (%RTP)	Core Power (MW)[a]	T_{cold} (°F)	T_{MFW} (°F)
85.0	2349.0	546.5	418.6
75.0	2079.0	544.8	407.8
65.0	1809.0	543.3	395.3
60.0	1674.0	542.2	389.0
55.0	1539.0	541.6	380.5
45.0	1269.0	539.7	363.5

Case	Pressurizer Level (%)	SG Level (%)
LOEL/TT primary cases	74.0	40.0
LOEL/TT secondary cases	64.0	70.0
Single MSIV Closure cases		85.0[b]
85% RTP	65.0	
75% RTP	63.7	
60% RTP	57.8	
45% RTP	51.9	

Table 4.2 Other Conditions

Parameter	Assumed Value
Core bypass flow	4% of total RCS flow (bounding value)
Steam generator tube plugging level	500 tubes per SG plugged for LOEL/TT primary cases, no tubes plugged for all other cases

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[a] Corresponds to % RTP for each case times 2700 MW, plus 54 MW (2% of 2700 MW) uncertainty.

[b] The MSIV closure model does not model the SG levels The model is initialized with SG inventories corresponding to 85% level.

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Table 4.3 Neutronic Feedback Conditions Assumed for all Cases

Parameter	Assumed Value
Moderator temperature coefficient[a] LOEL/TT primary cases LOEL/TT secondary cases Single MSIV Closure cases	+4 pcm/°F 0 pcm/°F -32 pcm/°F
Doppler coefficient LOEL/TT cases Single MSIV Closure cases	0.8 x most-negative value (at end-of-cycle) 0.9 x most-negative value (at end-of-cycle)[b]

Table 4.4 Reactor Trip Setpoints and Delays

Reactor Trip	Setpoint	Delay[c]
Low Steam Generator Pressure	658 psia	0.9 s
High Pressurizer Pressure	2422 psia	0.9 s

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[a] The LOEL/TT cases show almost no sensitivity to the MTC value because the high pressure trip occurs before there is a significant temperature change at the core inlet.

[b] It is conservative to minimize the Doppler coefficient because it minimizes the negative reactivity feedback from Doppler, which leads to higher peak power levels. The 0.8 multiplier was used in the LOEL/TT cases for consistency with the full power LOEL/TT analysis of record.

[c] The delays listed here are for signal processing and transmittal. An additional 0.5 second delay for release of the scram CEA holding coils must also transpire before scram CEA insertion begins.

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5.0   Loss of External Load Event

5.1   *Event Description*

A major load loss on the generator can result from the loss of external electrical load due to an electrical system disturbance. Offsite electrical power is available to operate the RCPs and other station auxiliaries. Following the loss of generator load, the turbine flow control system rapidly shuts off the steam flow and causes the secondary system pressure and temperature to increase, which in turn causes the primary temperature and pressure to increase.

If the reactor is not tripped when the turbine is tripped, primary system temperatures will continue to rise. The primary coolant will expand, compressing the pressurizer steam space and causing the pressurizer pressure to rise. The reactor will eventually scram on high pressurizer pressure, reducing the primary heat source. As the heat load on the primary system decreases, the primary system pressure will begin to diminish.

If the setpoint for opening the primary system safety valves is exceeded during the primary system over-pressurization, these valves will open to relieve pressure and mitigate the pressure transient. For the peak secondary system pressure cases analyzed, the pressurizer spray and PORVs were assumed to function. The action of the sprays minimizes the primary pressure increase, and delays the time of reactor scram. This maximizes the load the MSSVs must remove. The PORVs open concurrent with reactor scram and reduce the maximum primary system pressure; however, opening the PORVs does not affect the calculated peak secondary pressure or the MDNBR. For the peak primary system pressure cases analyzed, the pressurizer spray and PORVs were assumed to be unavailable.

During both sets of cases (i.e., primary over-pressurization and secondary over-pressurization), the MSSVs will open to relieve the pressure when the steam generator pressure exceeds the MSSVs' opening setpoints.

5.2   *Acceptance Criteria*

The LOEL/TT event is classified as a Condition II "Fault of Moderate Frequency" (expected to occur no more frequently than once per year). The acceptance criteria from the Standard Review Plan (Reference 3) for these events are:

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1.   The pressures in the reactor coolant and main steam systems should be less than 110% of design values.

2   The fuel cladding integrity should be maintained by ensuring SAFDLs are not exceeded. This is demonstrated by assuring that the minimum calculated MDNBR is not less than the applicable limits of the DNB correlation being used.

3.   The event should not generate a more serious plant condition without other faults occurring independently.

4.   For transients of moderate frequency in combination with a single failure, no loss of function of any fission product barrier, other than fuel element cladding, shall occur.

The principal acceptance criterion is the over-pressurization since thermal margins are greater in cases initiated from reduced power, compared to the event initiated at full rated power.

5.3   *Cases to be Analyzed*

Two sets of cases were analyzed at reduced power levels, one set for determining the primary over-pressurization and the other set for the secondary side over-pressurization. Each set was run with cases at initial reactor powers at 85%, 75%, 65%, and 55% RTP with from one MSSV to four MSSVs inoperable, respectively. In all cases, the lowest setpoint MSSVs in each steam line were disabled up to the desired number of inoperable valves.

5.4   *Primary Over-pressurization Analysis Results*

The analysis results for the four cases are given in the event summary, Table 5.1. Figure 5.1 through Figure 5 8 show the behavior of significant parameters during the transient initiated from 85% power. The behavior for the lower power cases is similar except for timing of significant events.

Figure 5.1 shows the reactor power level. The power level is seen to rise due to the positive moderator feedback reactivity as the coolant heats up. A reactor trip on high pressurizer pressure occurs at 6.11 seconds (4.71 seconds to reach 2422 psia, plus 0.9 second signal processing and 0.5 second scram coil dropout delay). The power drops rapidly following the trip as the scram reactivity is inserted.

Figure 5.2 shows the total reactivity during the transient. The reactivity response is similar to reactor power.

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Figure 5.3 shows the pressurizer pressure and pressure at the reactor vessel bottom. The pressurizer pressure reaches the high pressure trip setpoint of 2422 psia at 4.71 seconds. The pressurizer safety valves open at 6.8 seconds. The maximum pressure in the primary system occurs at the bottom of the reactor vessel. The peak pressure of 2716.3 psia is reached at 7.3 seconds. The difference from the indicated pressurizer pressure includes the elevation head and the flow losses from the bottom of the reactor vessel to the pressurizer.

Figure 5.4 shows the steam generator steam mass flow rates. The steam flows are seen to rapidly fall to zero as the turbine valves close. The steps in the steam flows starting at about 5 seconds are due to the MSSVs opening. Five of the seven operable MSSVs in each steam line were opened during the transient. The lowest setpoint valve was inoperable in each steam line for this case.

Figure 5.5 shows the flow rate through the primary system safety valves. Both valves show identical behavior. The flow is below the rated valve flow of 81.67 lbm/s because of the pressure drop in the inlet piping when the valve opens.

Figure 5.6 shows the pressurizer level response during the transient. The level is shown to rise due to the heatup and expansion of the primary coolant. It reaches a maximum level of about 83% at approximately 12 seconds into the transient.

Figure 5.7 shows the hot leg and cold leg coolant temperature response during the transient. The loss of load causes the RCS temperature to increase. The hot leg and cold temperatures are seen to decrease when the energy removed through the opened MSSVs is adequate to cool down the primary system.

Figure 5.8 shows the primary loop flow rates during the transient. The small change in flow simply reflects the changes in primary coolant temperature and density.

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Table 5.1 Event Summary for LOEL/TT Primary Overpressurization Calculations

Event	Time (s)			
	85% RTP	75% RTP	65% RTP	55% RTP
Initiation of transient, TCVs start to close	0.0	0 0	0 0	0.0
High Pressurizer Pressure trip setpoint reached	4.71	5.15	5.67	6.31
MSSVs open	5.3	6.4	8.0	10.1
Reactor Scram (start of CEA motion)	6.11	6.55	7.07	7.71
Pressurizer Safety Valves open	6.8	7 4	8 1	9.1
Peak primary pressure	7.3 (2716.3 psia)	7 8 (2712.5 psia)	8 5 (2709.5 psia)	9.4 (2703.4 psia)

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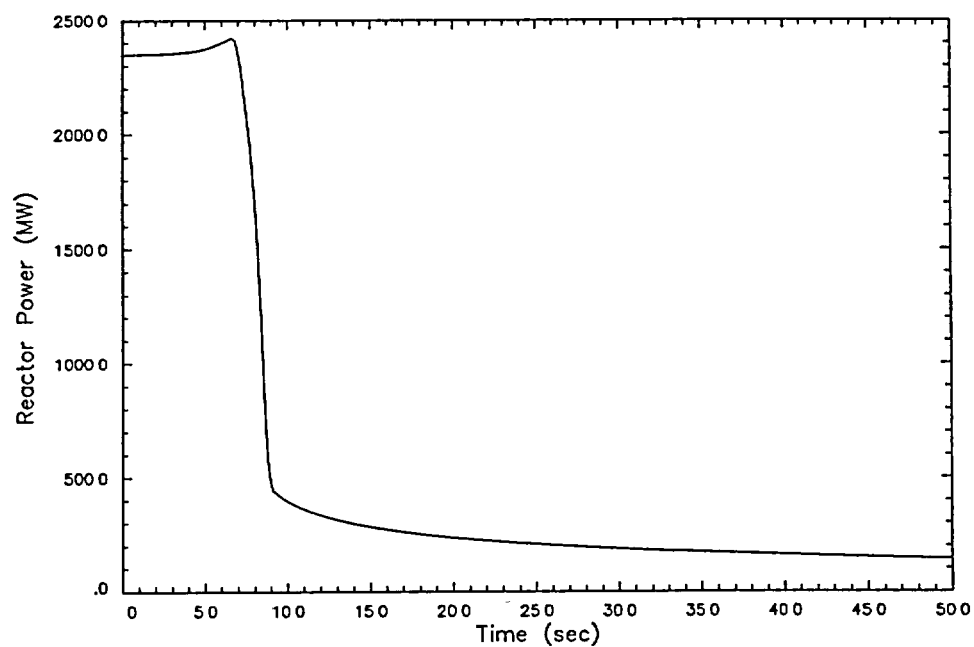
Figure 5.1 Reactor Power Level for LOEL/TT Primary
Overpressurization Event (Initiated from 85% RTP with one MSSV
inoperable per steam generator)

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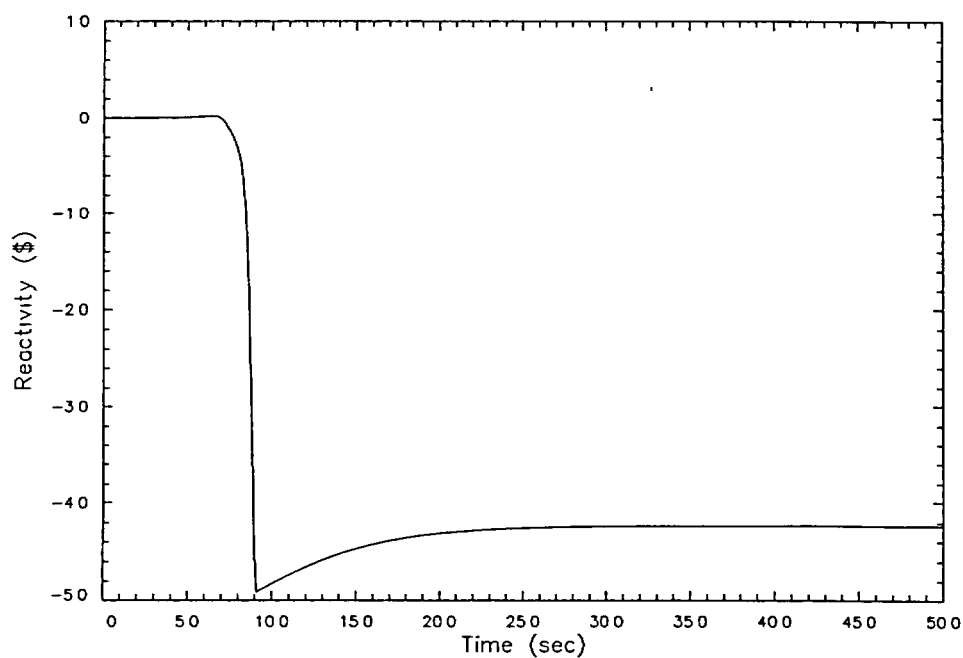
**Figure 5.2 Total Reactivity for LOEL/TT Primary Overpressurization
Event (Initiated from 85% RTP with one MSSV inoperable
per steam generator)**

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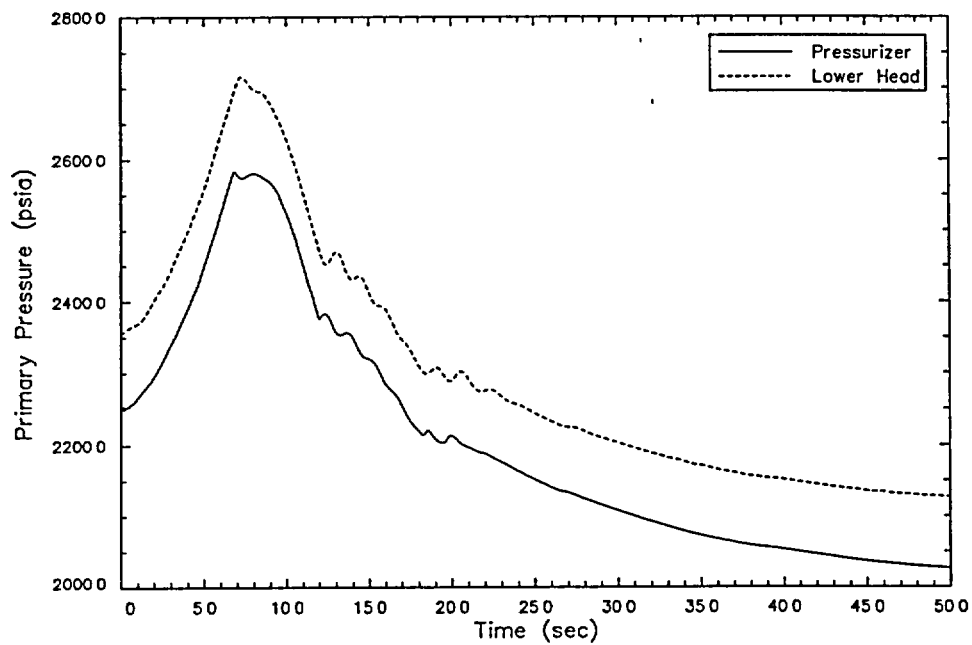
Figure 5.3 Primary System Pressures for LOEL/TT Primary
Overpressurization Event (Initiated from 85% RTP with one MSSV
inoperable per steam generator)

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Figure 5.4 Steam Generator Steam Flow Rates for LOEL/TT Primary
Overpressurization Event (Initiated from 85% RTP with one MSSV
inoperable per steam generator)

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**Figure 5.5 Primary Safety Valve Flow Rates for LOEL/TT Primary
Overpressurization Event (Initiated from 85% RTP with one MSSV
inoperable per steam generator)**

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Figure 5.6 Pressurizer Level for LOEL/TT Primary
Overpressurization Event (Initiated from 85% RTP with one MSSV
inoperable per steam generator)

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Figure 5.7 Hot and Cold Leg Temperatures for LOEL/TT Primary
Overpressurization Event (Initiated from 85% RTP with one MSSV
inoperable per steam generator)

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**Figure 5.8 Primary Total Flow Rate for LOEL/TT Primary
Overpressurization Event (Initiated from 85% RTP with one MSSV
inoperable per steam generator)**

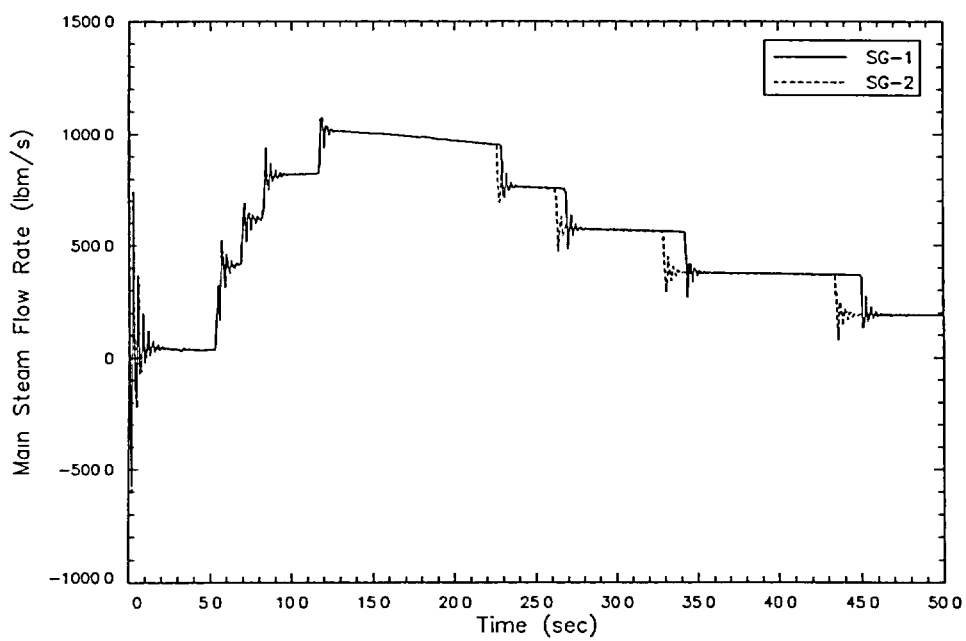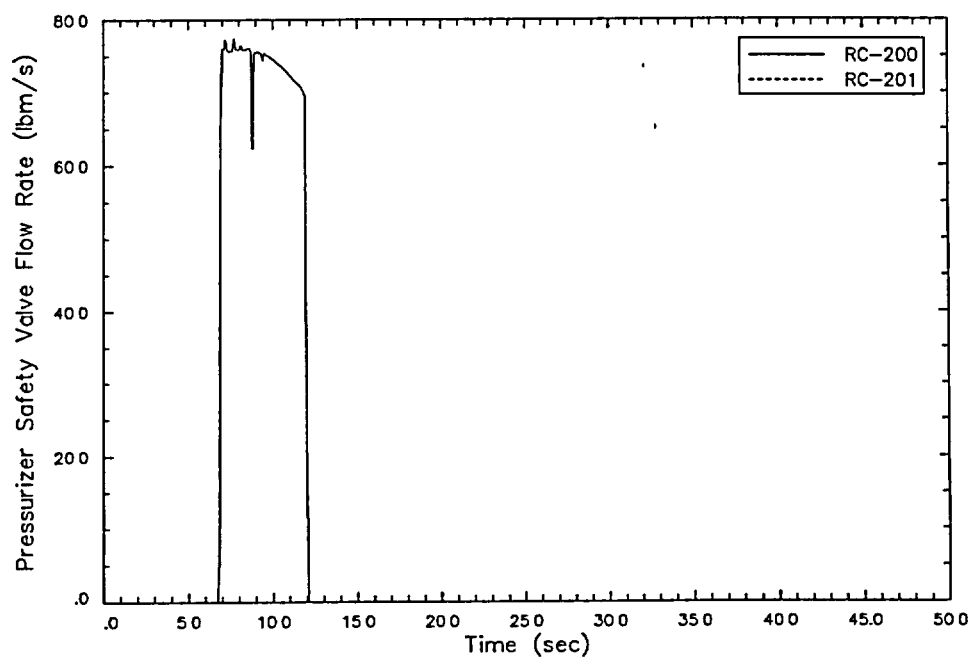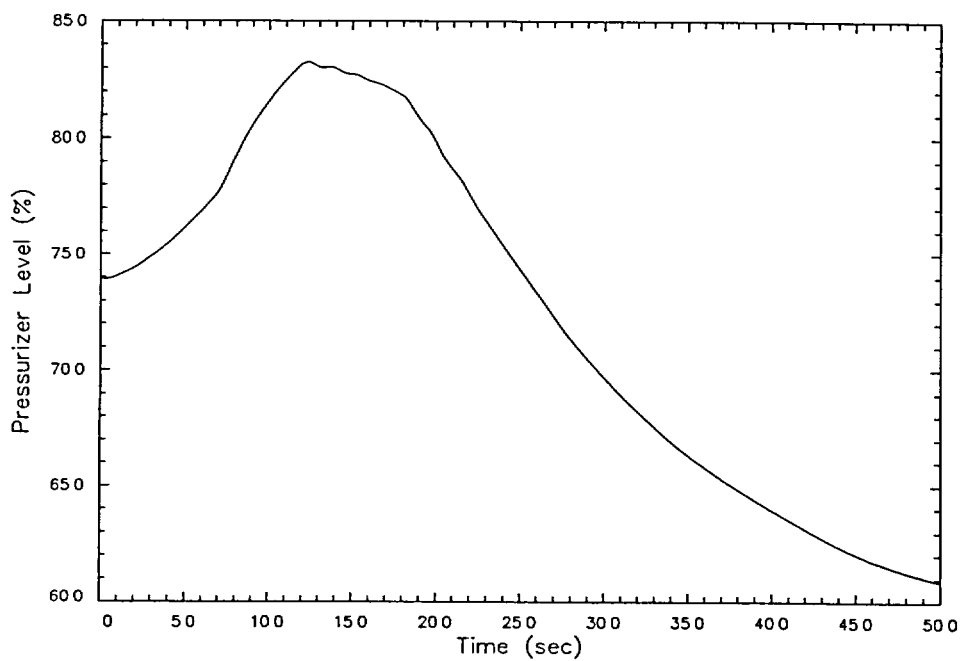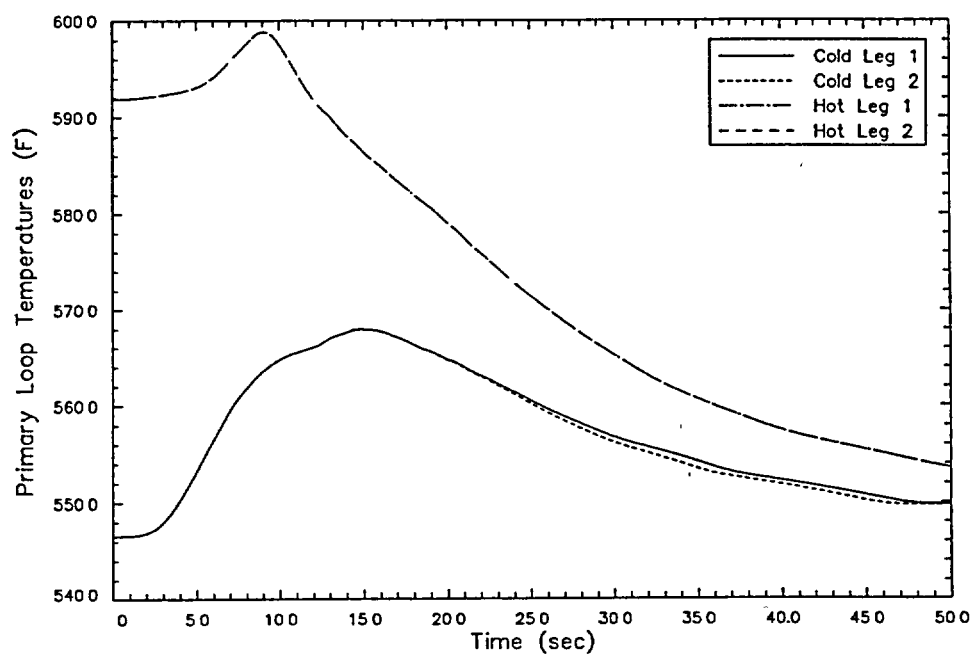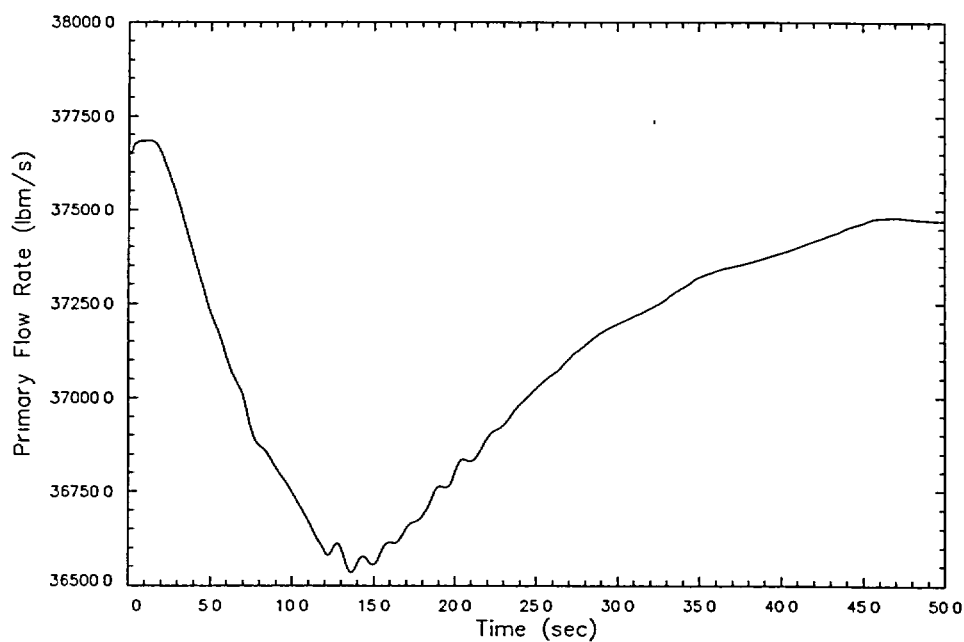Millstone Unit 2 Analysis of the Loss-of-External-Load/Turbine Trip and Single
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5.5 Secondary Over-pressurization Analysis Results

The analysis results for the four cases are given in the event summary, Table 5.2. Figure 5.9 through Figure 5.20 show the behavior of significant parameters during the transient initiated from 85% power. The behavior for the lower power cases is similar except for timing of significant events.

Figure 5.9 shows the reactor power level. The power level remains constant until the time of reactor trip due to the zero moderator feedback reactivity. A reactor trip on high pressurizer pressure occurs at 6.8 seconds (5.4 seconds to reach 2422 psia, plus 0.9 second signal processing and 0.5 second scram coil dropout delay). The power drops rapidly following the trip as the scram reactivity is inserted.

Figure 5.10 shows the total reactivity during the transient. The reactivity response is similar to reactor power.

Figure 5.11 shows the pressurizer pressure and reactor vessel lower head pressure. The pressurizer spray valve opened at 3.7 seconds. The pressure reaches the high pressure trip setpoint of 2422 psia at 5.4 seconds. The pressurizer PORVs and the primary system safety valves open at 5.5 seconds.

Figure 5.12 shows the steam generator steam flow rates. The steam flows are seen to rapidly fall to zero as the turbine valves close. The step changes in the steam flows starting at about 5 seconds are from the MSSVs opening. Both steam lines are seen to behave nearly identically.

Figure 5.13 shows the maximum secondary side pressure throughout the transient, which occurs at the bottom of the boiler region. The pressure is calculated at the bottom of the boiler region, just above the tubesheet. Both steam generators behave nearly identically. The peak secondary side pressure for SG-1 (slightly higher than SG-2) was 1086.3 psia at 13.1 seconds into the transient.

Figure 5.14 shows the mass flow rate for the lowest 4 setpoint MSSVs in one steam line. Figure 5.15 shows the flow through the highest 4 setpoint MSSVs in the same steam line. The other steam line showed essentially identical results. These figures show that five valves opened fully. The lowest setpoint valve in each steam line was inoperable in this case. The mass flow rates are not as high as the rated valve flow of 220.6 lbm/s because of the pressure drop in the

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inlet piping when the valve opens. Also, the flow rates are lower than the rated flows because the MSSVs open at lower pressures than the rated pressure.

Figure 5.16 and Figure 5.17 show the MSSV inlet pressure for the five MSSVs which opened during the transient. The pressure in the inlet piping to each MSSV is shown to rapidly drop about 60 psi as the valve opens   The pressure remains above the closing pressure, but the pressure reduction causes the valve to pass less flow than the rated flow. The fact that not all MSSVs opened in this analysis shows that there is additional protection against secondary overpressurization for a LOEL event.

Figure 5.18 shows the pressurizer level response during the transient   The level is shown to rise due to the heatup and expansion of the primary coolant. It reaches a maximum level of about 73% at approximately 12 seconds into the transient.

Figure 5.19 shows the hot leg and cold leg coolant temperature responses during the transient. The loss of load causes both the hot leg and cold leg temperatures to increase. The hot leg and cold leg temperatures are seen to decrease when the energy removed through the opened MSSVs is adequate to cool down the primary system.

Figure 5.20 shows the primary loop mass flow rates during the transient. The slight change in flow simply reflects the changes in primary coolant temperature and density.

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**Table 5.2 Event Summary for LOEL/TT Secondary
Overpressurization Calculations**

Event	Time (s)			
	85% RTP	75% RTP	65% RTP	55% RTP
start of transient, TCVs start to close	0.0	0.0	0.0	0.0
Pressurizer sprays open	3.7	4.1	4.6	5.2
MSSVs open	5.1	6.5	8.6	11.7
High Pressurizer Pressure trip setpoint reached	5.4	5.94	6.6	7.47
Pressurizer PORVs open	5.5	6.0	6.7	7.5
Pressurizer Safety Valves open	5.5	6.1	6.7	7.6
Reactor Scram (start of CEA motion)	6.8	7.3	8.0	8.9
Peak secondary pressures	13.1 (1086.3 psia)	14.3 s (1087.4 psia)	15.7 (1088.4 psia)	17.9 (1088.1 psia)

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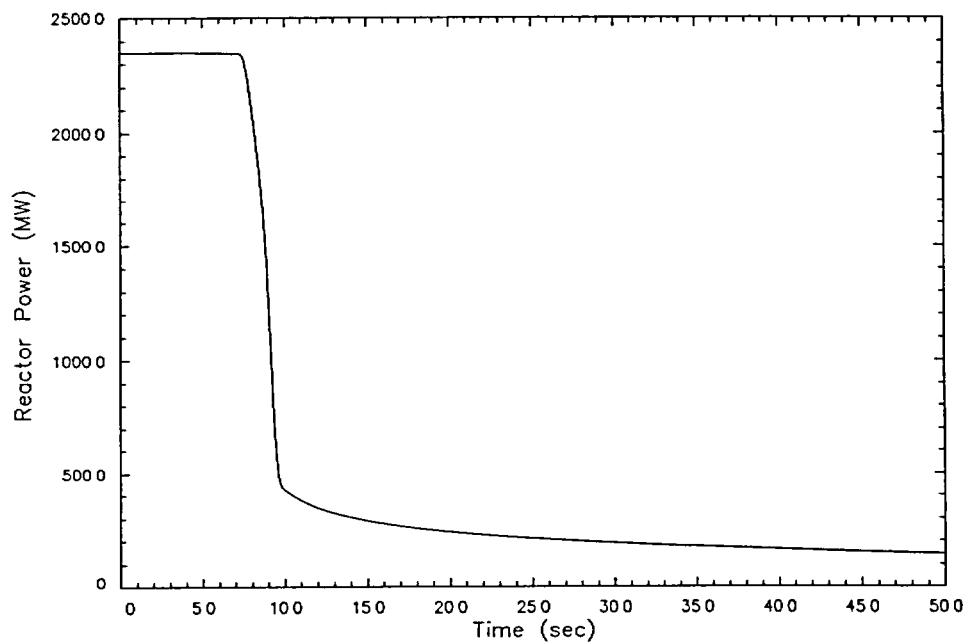
Figure 5.9 Reactor Power Level for LOEL/TT Secondary
Overpressurization Event (Initiated from 85% RTP with one MSSV
inoperable per steam generator)

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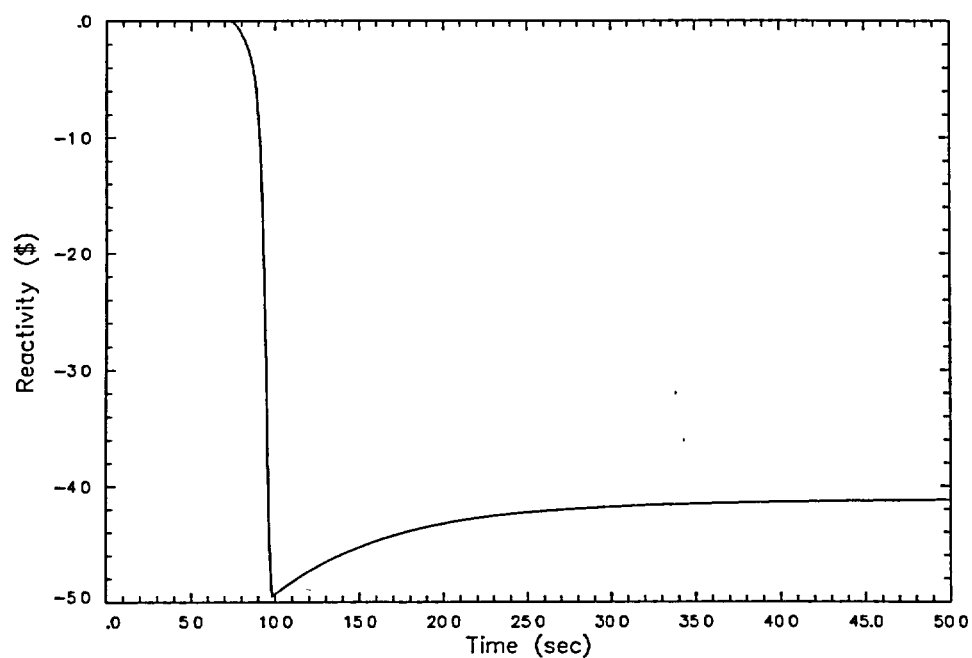
**Figure 5.10 Total Reactivity for LOEL/TT Secondary
Overpressurization Event (Initiated from 85% RTP
with one MSSV inoperable per steam generator)**

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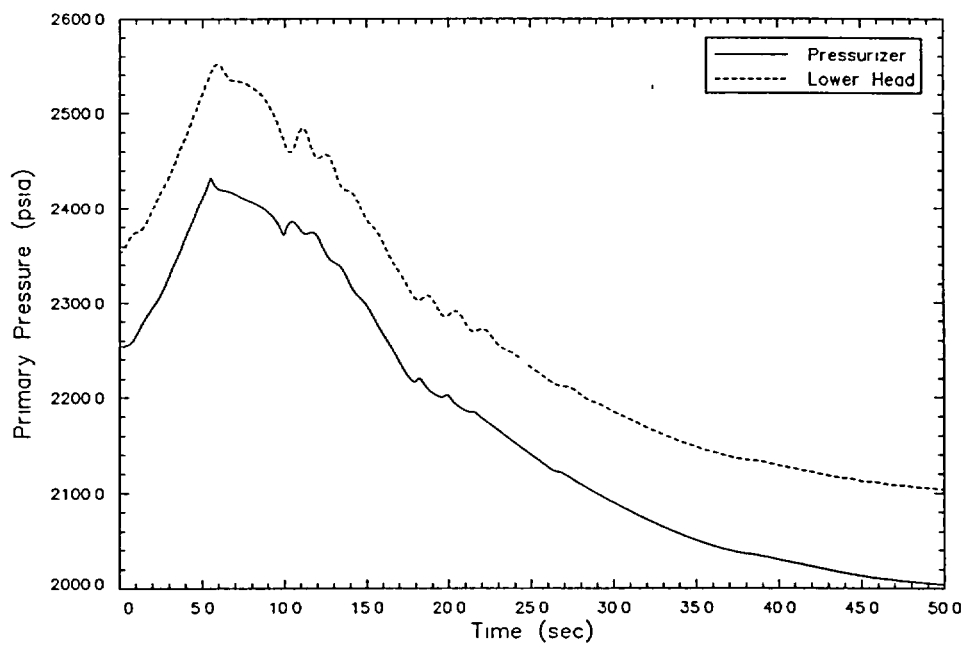
Figure 5.11 Primary Pressures for LOEL/TT Secondary
Overpressurization Event (Initiated from 85% RTP
with one MSSV inoperable per steam generator)

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**Figure 5.12 Steam Generator Steam Flow Rates for LOEL/TT
Secondary Overpressurization Event (Initiated from 85% RTP
with one MSSV inoperable per steam generator)**

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**Figure 5.13 Peak Secondary System Pressure for LOEL/TT
Secondary Overpressurization Event (Initiated from 85% RTP
with one MSSV inoperable per steam generator)**

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**Figure 5.14 Four Lowest Setpoint MSSVs Flow Rates for LOEL/TT
Secondary Overpressurization Event (Initiated from 85% RTP with
one MSSV inoperable per steam generator)**

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**Figure 5.15 Four Highest Setpoint MSSVs Flow Rates for LOEL/TT
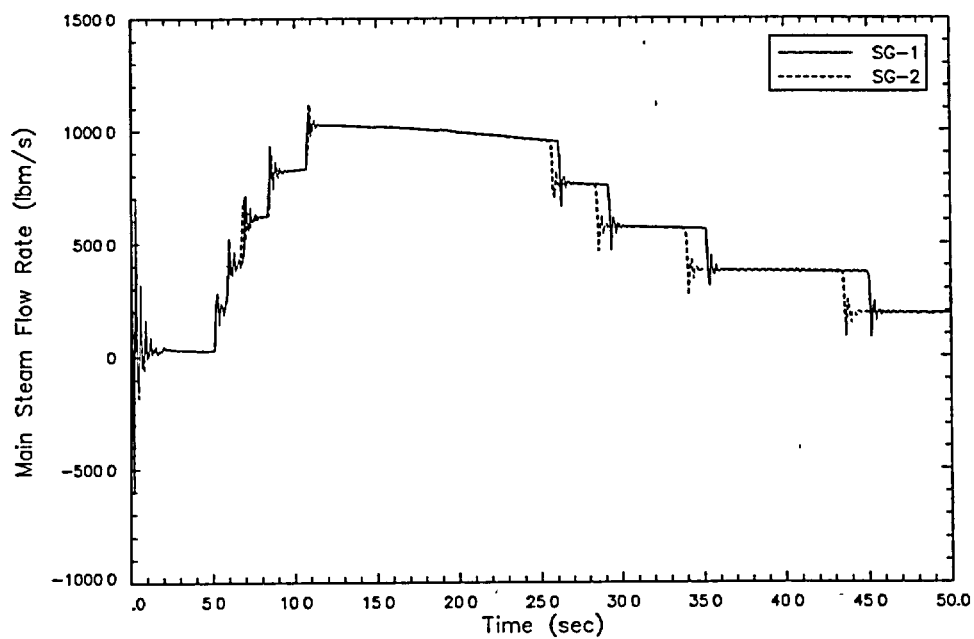Secondary Overpressurization Event (Initiated from 85% RTP with
one MSSV inoperable per steam generator)**

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Figure 5.16 Four Lowest Setpoint MSSVs Inlet Pressures for
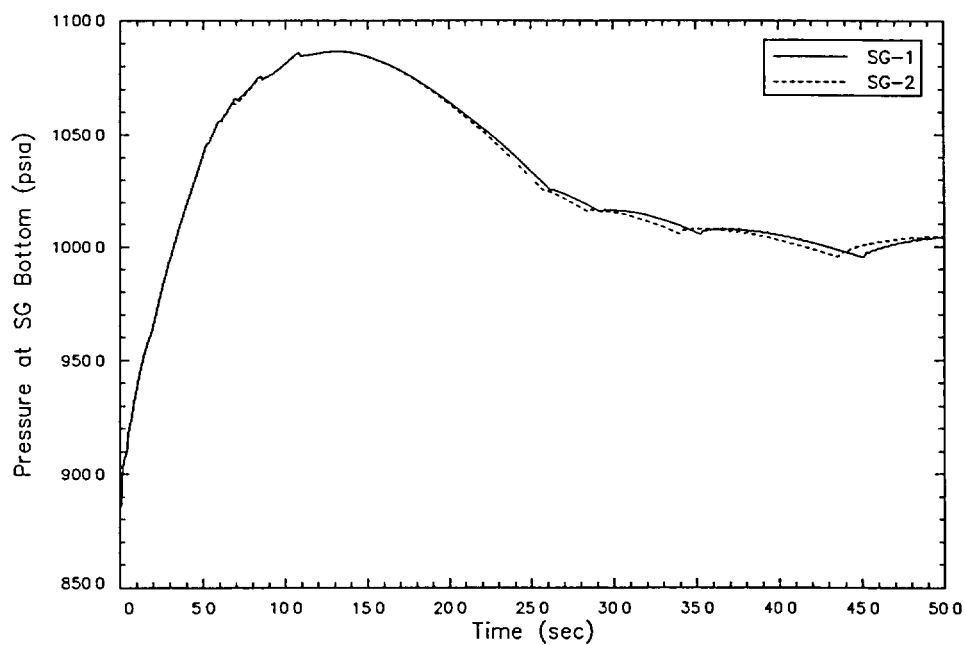LOEL/TT Secondary Overpressurization Event (Initiated from
85% RTP with one MSSV inoperable per steam generator)

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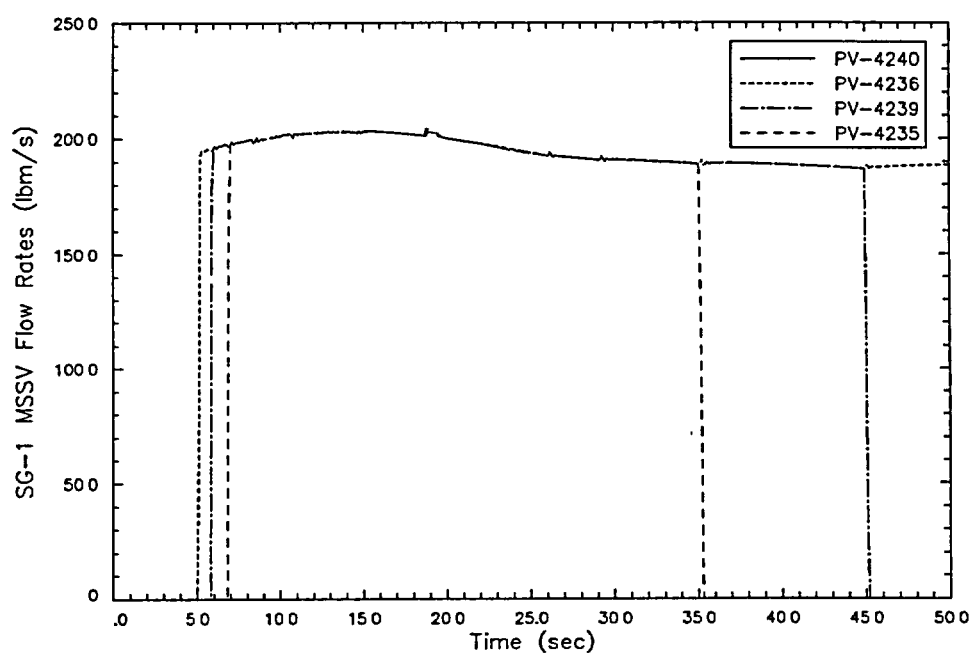**Figure 5.17 Four Highest Setpoint MSSVs Inlet Pressures for LOEL/TT Secondary Overpressurization Event (Initiated from 85% RTP with one MSSV inoperable per steam generator)**

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Figure 5.18 Pressurizer Level for LOEL/TT Secondary
Overpressurization Event (Initiated from 85% RTP
with one MSSV inoperable per steam generator)

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Figure 5.19 Hot and Cold Leg Temperatures for LOEL/TT Secondary Overpressurization Event (Initiated from 85% RTP with one MSSV inoperable per steam generator)
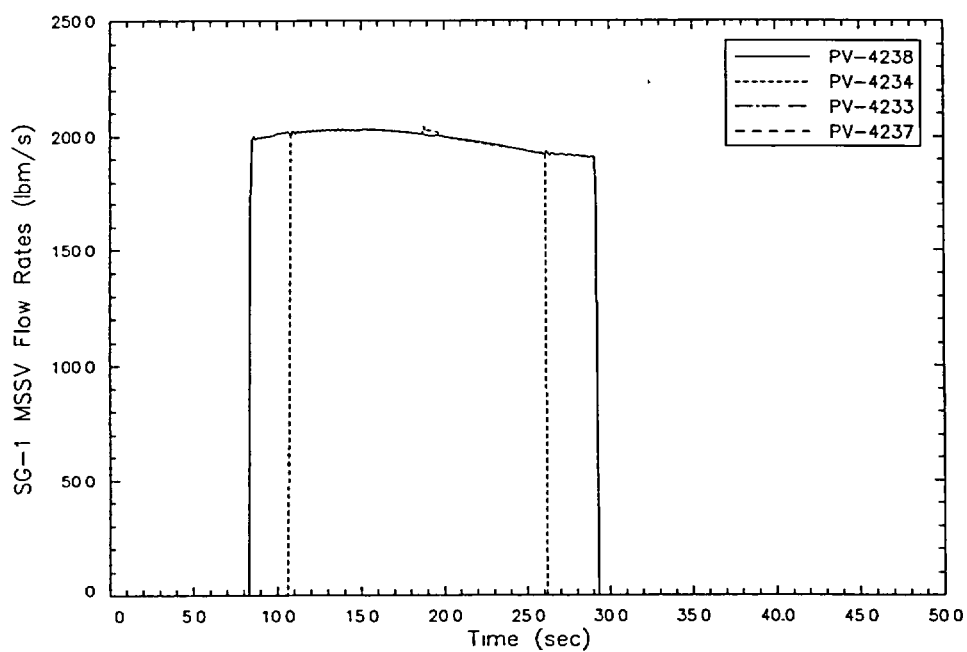
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**Figure 5.20 Primary Total Loop Flow Rate for LOEL/TT Secondary
Overpressurization Event (Initiated from 85% RTP with one MSSV
inoperable per steam generator)**

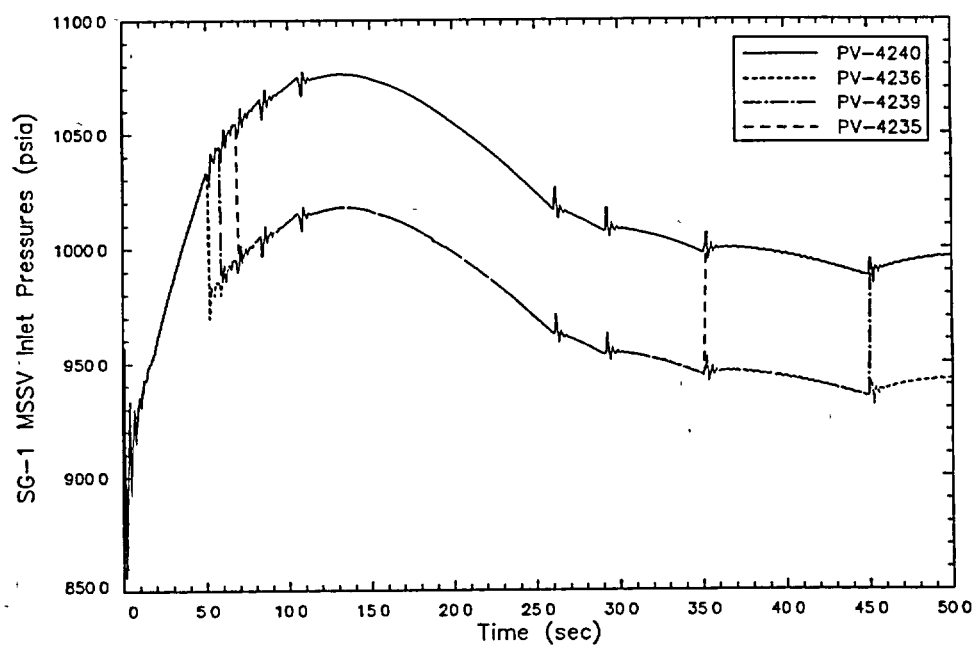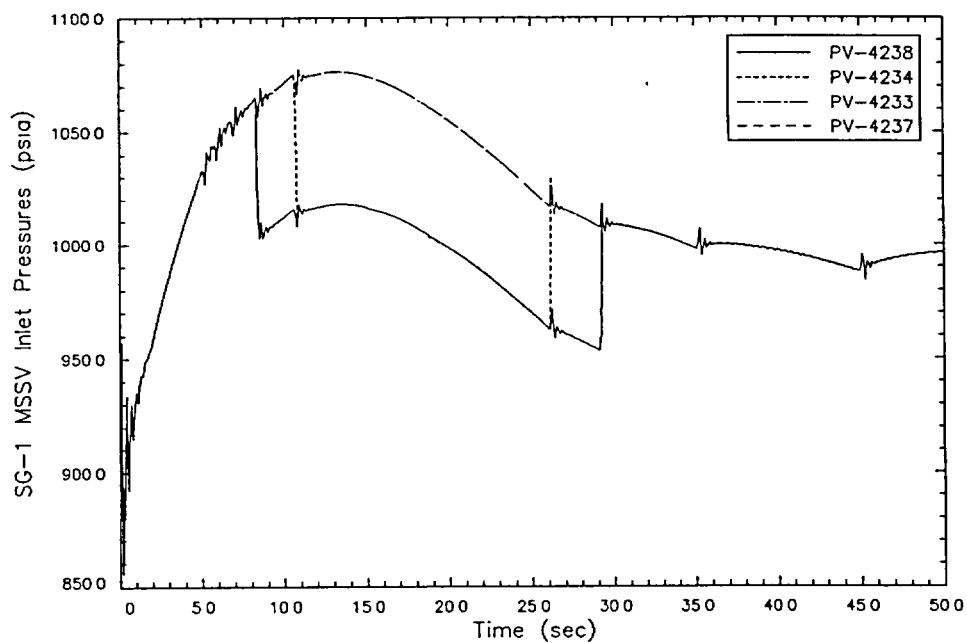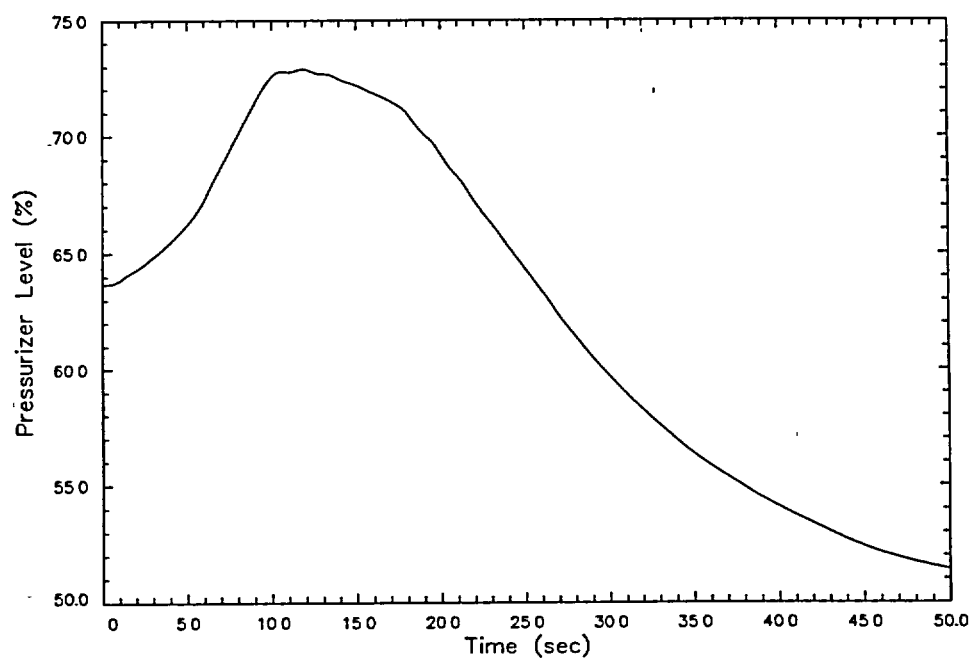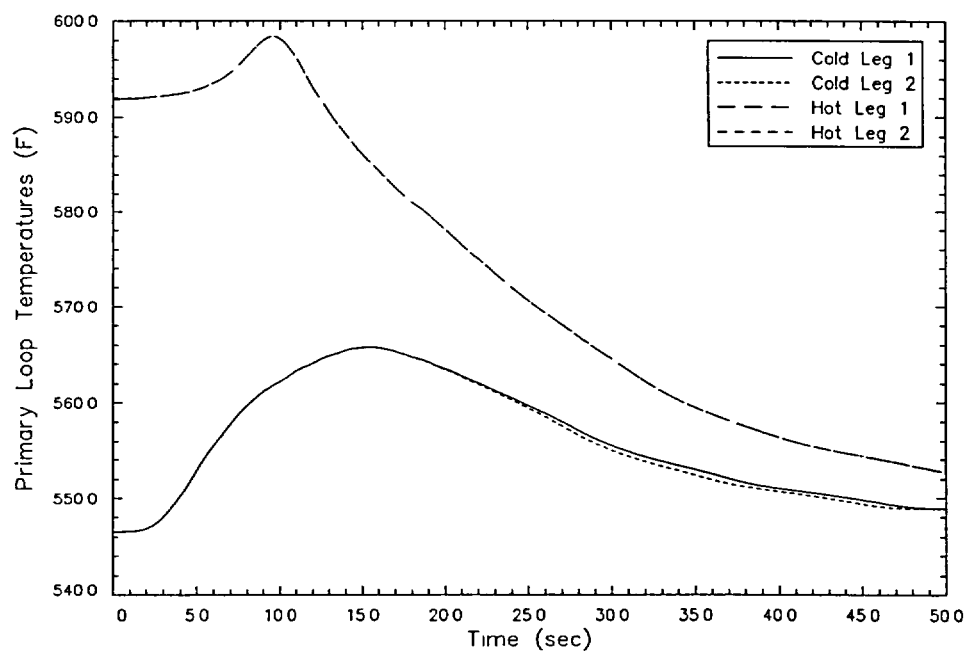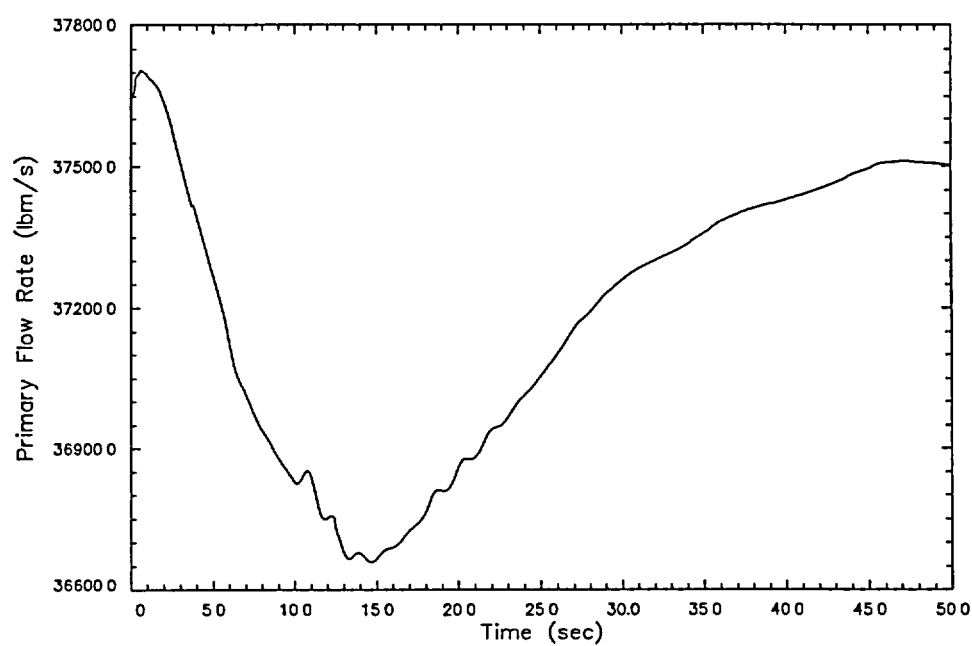Millstone Unit 2 Analysis of the Loss-of-External-Load/Turbine Trip and Single
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6.0   Inadvertent Closure of a Single MSIV Event

6.1   *Event Description*

The event is initiated by the loss of control air to one of the two MSIVs in a plant which lacks asymmetric steam system protection logic. An MSIV is a swing-check valve held open during normal operation by a pneumatic control system. The loss of control air to one of the MSIVs causes it to close. The termination of the steam flow from the steam generator associated with the closed MSIV initiates a heatup of that steam generator and its associated primary coolant loop. The increase in steam flow from the other steam generator (which now must meet the entire plant load demand) initiates a cooldown of the steam generator and its associated primary coolant loop. Due to the lack of asymmetric steam system protection logic, the event is not terminated until reactor scram on low steam generator pressure or variable high power.

The heatup of the steam generator and primary coolant loop associated with the closed MSIV is limited by MSSV actuation. (Normally, the principal limitation to this heatup would be provided by the steam dump system and the atmospheric dump valves, but safety analysis does not take credit for these non-safety-grade features.) The cooldown of the other steam generator and its primary loop continues throughout the transient event until the turbine trips at reactor scram. Because the coolant inlet temperature decrease of the half of the core associated with the open MSIV exceeds the temperature increase of the other half of the core, negative moderator feedback results in an overall increase in reactor power, which is eventually terminated by the reactor scram on low steam generator pressure or variable high power.

Main feedwater is isolated from the steam generator associated with the closed MSIV when the MSIV closes (at transient initiation). This scenario conservatively bounds the reduction in feedwater flow that would occur during the transient. Main feedwater to the steam generator associated with the open MSIV is allowed to match steam demand from the steam generator.

6.2   *Acceptance Criteria*

The MSIV Closure event is classified as a Condition II "Fault of Moderate Frequency" (expected to occur no more frequently than once per year).

The following Standard Review Plan (Reference 3) acceptance criteria can potentially be challenged by this event:

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1   The steam system pressure should be less than 110% of the design pressure (1100 psia).

2.   The probability must exceed 95% at a 95% confidence level that none of the fuel rods in the core experience DNB. For a mixed core of the FRA-ANP designed Millstone Unit 2 fuel, this criterion is met if the MDNBR is greater than the 95/95 DNBR safety limit of the HTP DNB correlation, including a mixed core penalty.

3.   None of the fuel rods in the core may experience centerline melt. This criterion is met if the peak LHR is less than the fuel centerline melt LHR limit.

Since the thermal margins for the event initiated at reduced power are greater than at full rated power, the over-pressurization criterion is the limiting consideration in this analysis.

6.3   *Cases to be Analyzed*

Two separate scenarios are analyzed for this event at full rated power to bound operation of the steam flow control system, which determines steam flow through the open MSIV. In the first case, the flow area of the TCV is held constant throughout the transient at the steady-state operating value. In the second scenario, the steam flow through the open MSIV is modeled by imposing a time-dependent junction component with flow specified as a function of pressure. A comparison of the steam flow through the open MSIV in the two scenarios shows that the steam flow is greater with flow versus pressure modeling. The results from these scenarios show that the peak secondary pressures are virtually identical. The modeling for the cases reported here, with reduced initial power levels and inoperable MSSVs, used the first scenario, with a constant TCV area.

Cases for a Single MSIV Closure transient were run at initial power levels of 85%, 75%, 60% and 45% RTP with from one MSSV to four MSSVs inoperable, respectively. It was found that a slightly higher peak secondary pressure occurred in the higher power cases by disabling the highest setpoint MSSVs. Therefore, in the 85% and 75% cases, the highest setpoint MSSVs in each steam line (up to the desired number of inoperable valves) were disabled, and in the 60% and 45% cases, the lowest setpoint MSSVs in each steam line (up to the desired number of inoperable valves) were disabled. In order to be conservatively bounding, no credit is taken for the Variable High Power Trip.

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6.4   *Single MSIV Closure Analysis Results*

The analysis results for the four cases are given in the event summary, Table 6.1. Figure 6.1 through Figure 6.10 show the behavior of significant parameters during the transient initiated from 85% of rated thermal power. The responses from the other cases initiated from lower power levels are similar.

Figure 6.1 shows the reactor power response. Initially, the reactor power starts to decline and then increases due to moderator feedback. The power increase is terminated by reactor scram which occurs at 24.8 seconds on low steam generator pressure (23.4 seconds to reach 658 psia, plus 0.9 second signal processing delay and 0.5 second scram coil dropout delay) in the loop with the open MSIV.

Figure 6.2 shows the steam flow rates at the outlets of the two steam generators. The flow in the loop with the open MSIV rapidly rises to nearly twice its initial flow to pick up the demand from the isolated steam generator. The isolated steam generator steam flow rate decreases as the MSIV is closed, then rises and falls as the MSSVs open and close.

Figure 6.3 shows the steam dome pressures of the two steam generators. The pressure in the isolated steam generator rises, while the pressure in the open generator decreases to the low steam generator pressure setpoint of 658 psia at 23.4 seconds.

Figure 6.4 shows the steam generator pressure at the bottom of the boiler region for the steam generator with the closed MSIV. The pressure of the isolated side rises to a peak value of 1092.2 psia at 20.0 seconds, just as the last MSSV opens. The pressure then begins to drop as the energy released through the open MSSVs exceeds the energy transferred from the primary system.

Figure 6.5 shows the steam flow rates through the first four MSSVs (those with the lowest pressure setpoints). Figure 6.6 shows the flows through the four MSSVs with the highest pressure setpoints. These figures indicate that all seven of the operable MSSVs open during the event. One valve with the highest opening setpoint was disabled in this case. The first MSSV opens at 5.35 seconds, and the last MSSV opens at 19.92 seconds. The mass flow rates are not as high as the rated valve flow of 220.6 lbm/s because of the pressure drop in the inlet piping when the valve opens. Also the mass flow rates are lower than the rated flows because the MSSVs open at a lower pressure than the rated pressure.

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MSIV Closure Events With Inoperable MSSVs
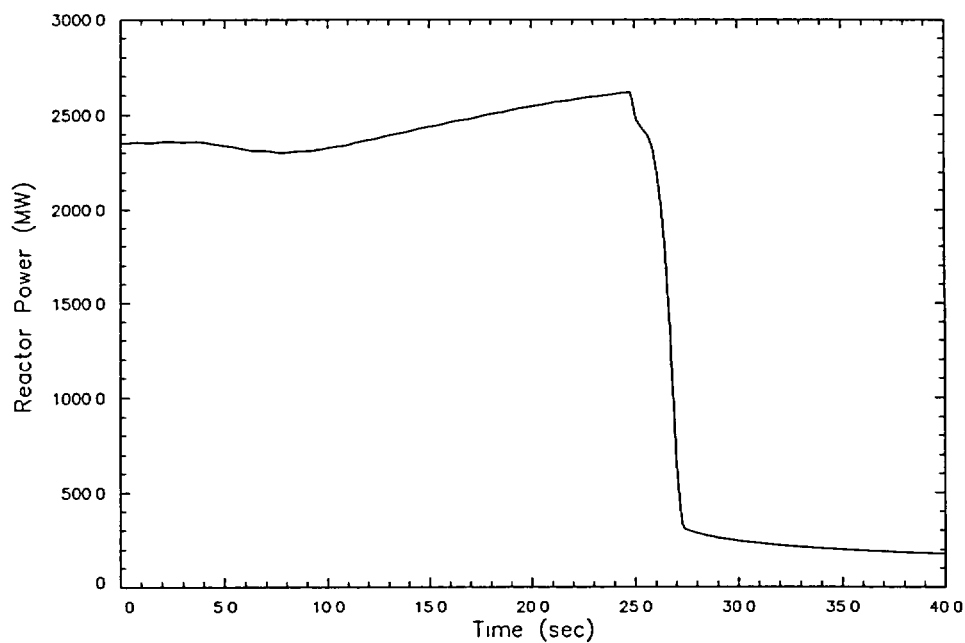
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Figure 6.7 and Figure 6.8 show the pressure in the inlet piping for each MSSV. These figures show that the pressure in each MSSV inlet pipe rapidly increases to the valve opening setpoint and then drops immediately after the valve opens due to the pressure losses in the MSSV inlet piping. The pressures in these volumes then slowly decrease, causing some of the MSSVs to close. When an MSSV closes, the pressure in the inlet pipe rises to the static pressure in the steam line.

Figure 6.9 shows the pressurizer collapsed liquid level. The level slightly increases prior to the time of reactor scram. Once reactor scram occurs, the pressurizer level begins to decrease.

Figure 6.10 shows the cold leg coolant temperature response in each loop during the transient. The asymmetric response of the loop temperatures is caused by the closure of a single MSIV. Following reactor scram at 24 8 seconds, the temperatures in both loops drop The temperatures in the loop with the open MSIV decrease more rapidly after scram because of the mismatch between steam flow and reactor power, where reactor power falls rapidly following scram, but closure of the open MSIV on low steam generator pressure is not modeled.

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Table 6.1 Event Summary for Single MSIV Closure Calculations

Event	Time (s)			
	85% RTP	75% RTP	60% RTP	45% RTP
Start of transient, one MSIV closes	0.0	0.0	0.0	0.0
First MSSV opens	5.35	6.48	10.75	17.3
Peak Pressurizer Pressure	12.3	13.8	16.2	22.5
Peak SG Secondary Pressure	20.0 (1092.2 psia)	32.0 (1090.9 psia)	15.2 (1085.1 psia)	68.5 (1086.2 psia)
Intact SG Pressure reaches low setpoint	23.4	27.5	37.9	63.9
Last MSSV opens	19.92	20.24	15.27	20.2
Reactor Scram (start of CEA motion)	24.8	28.9	39.3	65.3
Peak reactor Power	24.8	28.9	39.2	65.2
End of Calculation	40.0	40.0	60.0	80.0

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**Figure 6.1 Reactor Power Level for Single MSIV Closure Analysis
(Initiated from 85% RTP with one MSSV inoperable per steam
generator)**

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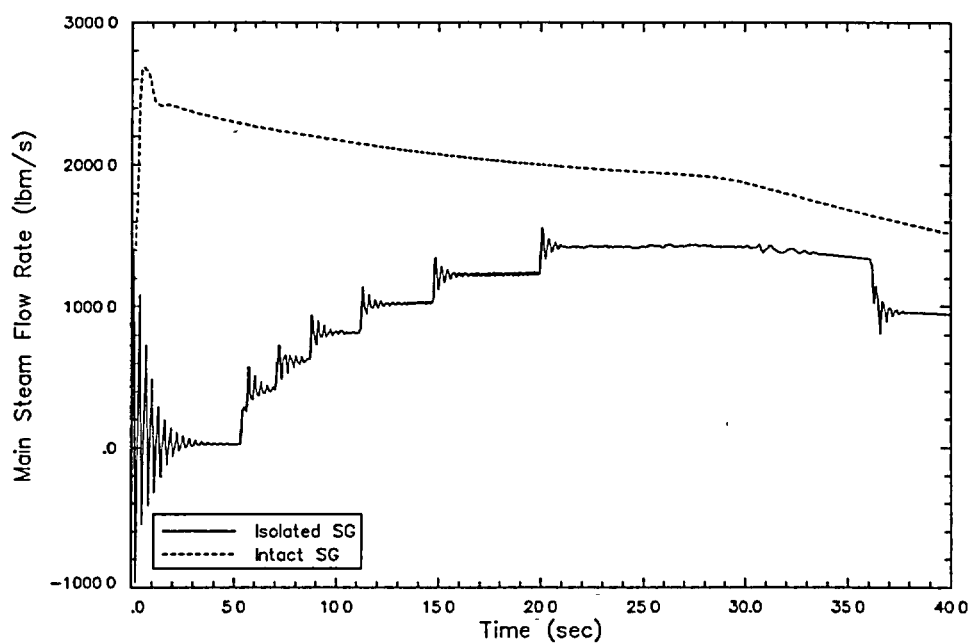
**Figure 6.2 Steam Flow Rates for Single MSIV Closure Analysis
(Initiated from 85% RTP with one MSSV inoperable per steam
generator)**

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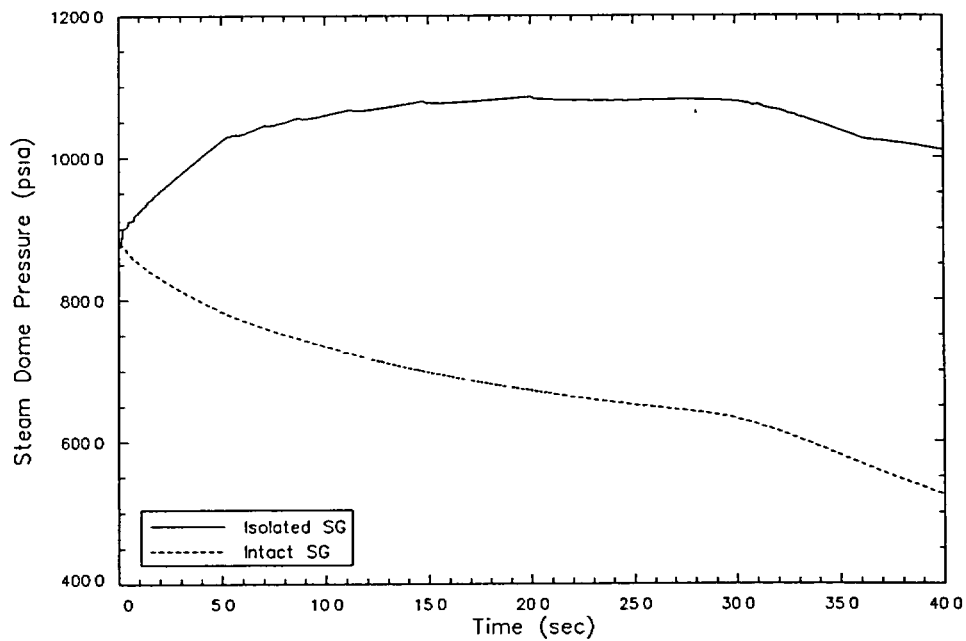
Figure 6.3 Steam Generator Dome Pressures for Single MSIV
Closure Analysis (Initiated from 85% RTP with one MSSV
inoperable per steam generator)

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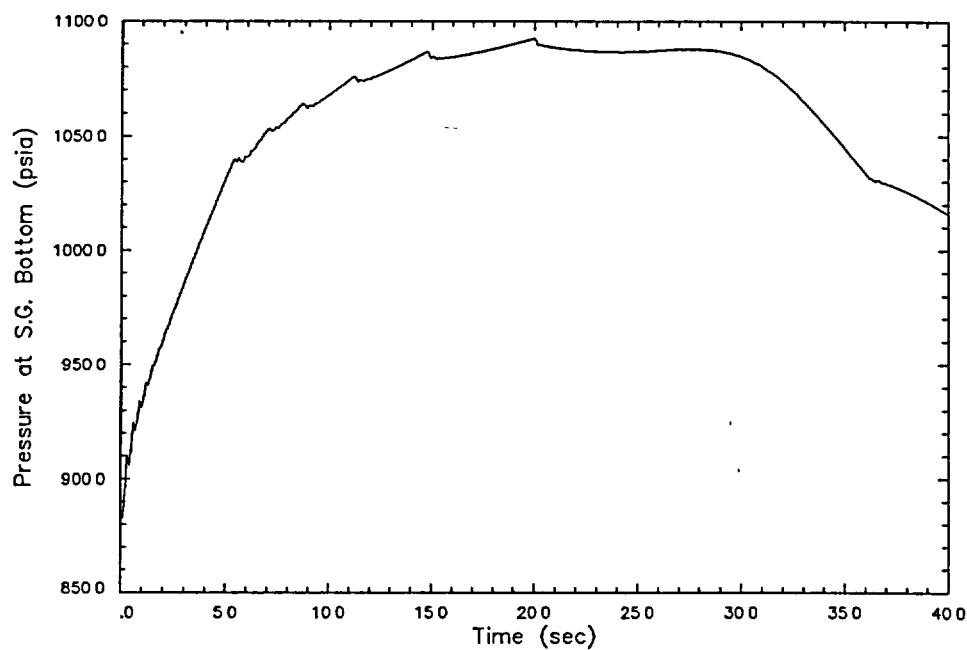
Figure 6.4 Isolated Steam Generator Pressure at Bottom of Boiler Region for Single MSIV Closure Analysis (Initiated from 85% RTP with one MSSV inoperable per steam generator)

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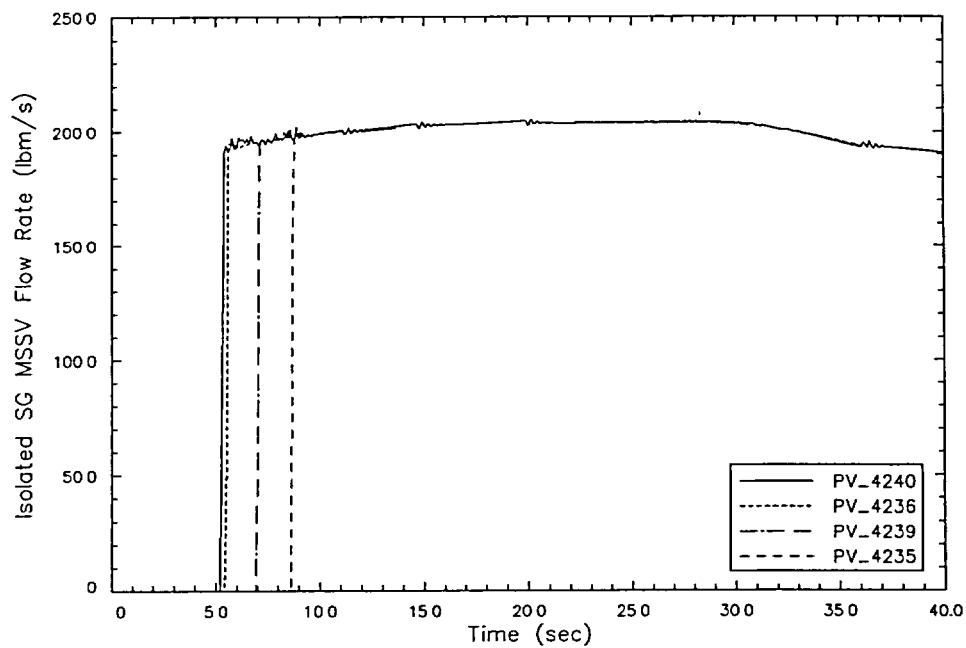
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Figure 6.5 Four Lowest Setpoint MSSVs Flow Rates for Single MSIV
Closure Analysis (Initiated from 85% RTP with one MSSV
inoperable per steam generator)

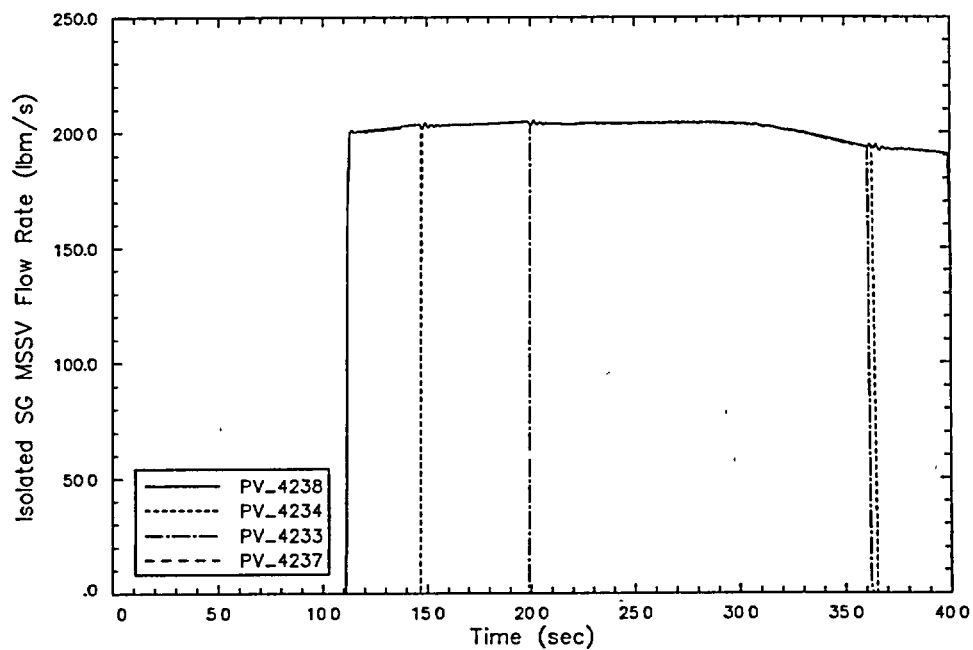Millstone Unit 2 Analysis of the Loss-of-External-Load/Turbine Trip and Single
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**Figure 6.6 Four Highest Setpoint MSSVs Flow Rates for Single MSIV
Closure Analysis (Initiated from 85% RTP with one MSSV
inoperable per steam generator)**

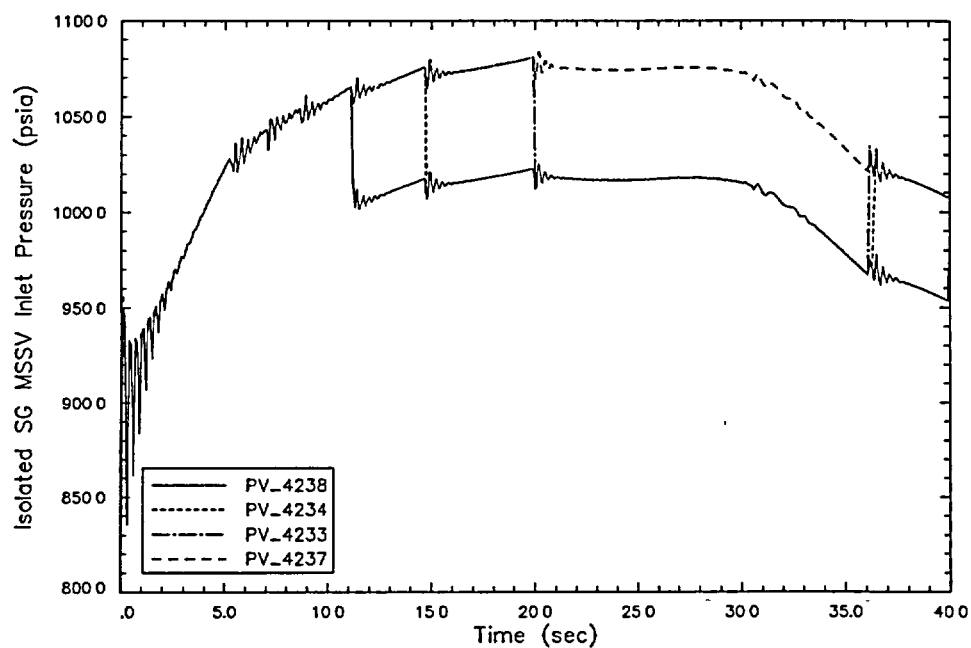Millstone Unit 2 Analysis of the Loss-of-External-Load/Turbine Trip and Single
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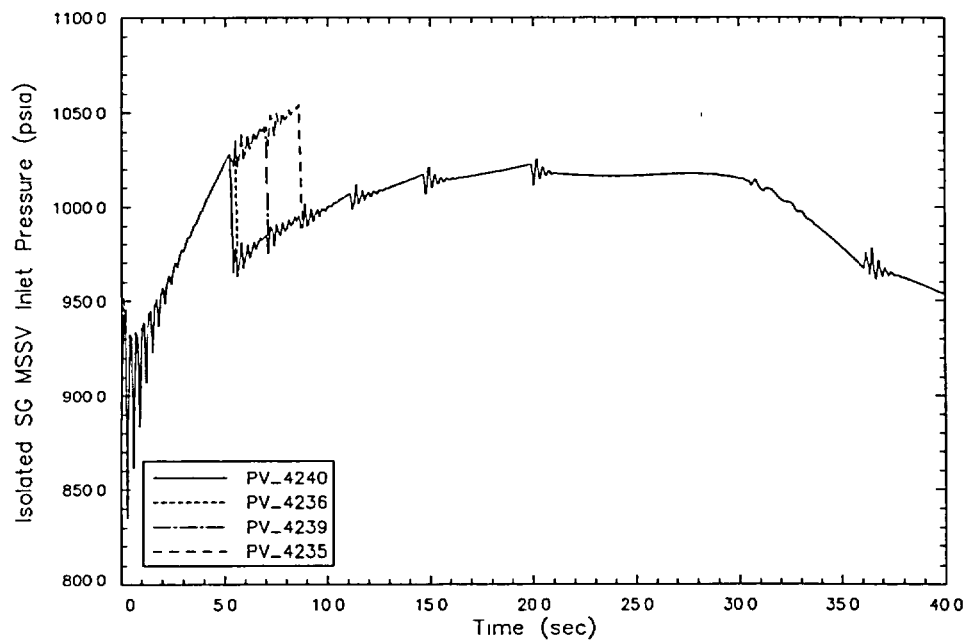
Figure 6.7 Four Lowest Setpoint MSSVs Inlet Pressures for Single MSIV Closure Analysis (Initiated from 85% RTP with one MSSV inoperable per steam generator)

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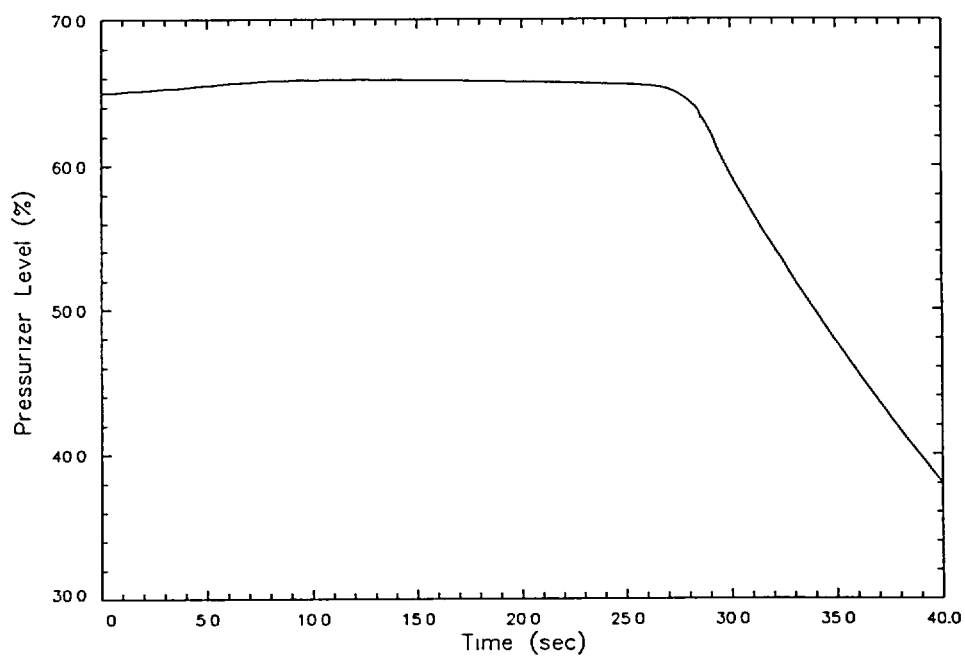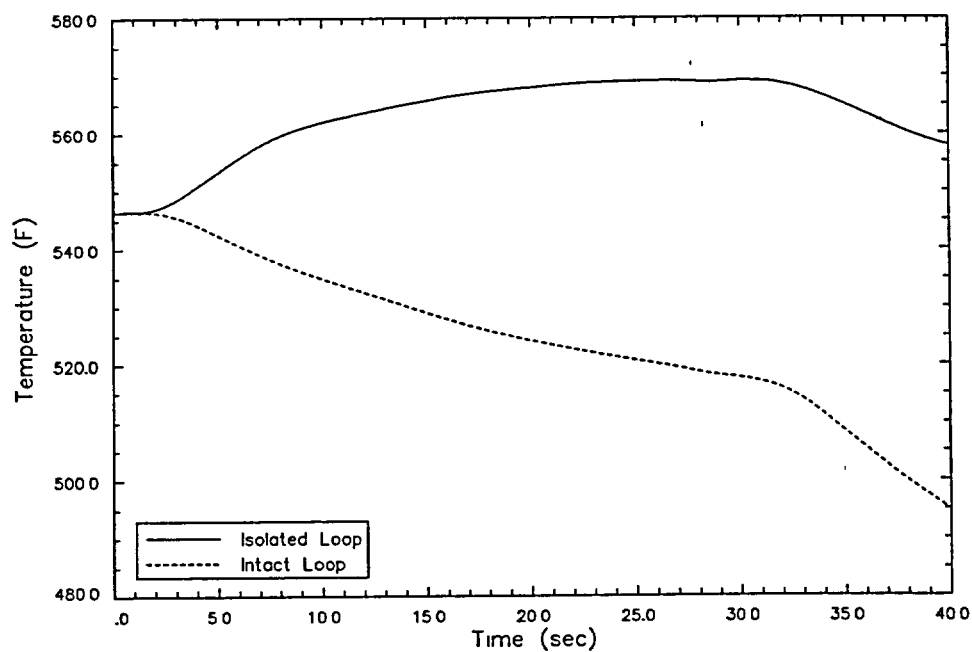
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**Figure 6.8 Four Highest Setpoint MSSVs Inlet Pressure for Single
MSIV Closure Analysis (Initiated from 85% RTP with one MSSV
inoperable per steam generator)**

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**Figure 6.9 Pressurizer Level for Single MSIV Closure Analysis
(Initiated from 85% RTP with one MSSV inoperable per steam
generator)**

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**Figure 6.10 Cold Leg Temperatures for Single MSIV Closure
Analysis (Initiated from 85% RTP with one MSSV
inoperable per steam generator)**

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